RANGE IMPROVEMENT

NOTES

SEPTEMBER 1979

INDEX

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE, INTERMOUNTAIN REGION
OGDEN, UTAH

STATEMENT OF PUBLICATION PURPOSE

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This publication is printed primarily to inform professional range administrators of important range improvement and management developments and findings. These "NOTES" may include extracts of published papers, unpublished preliminary reports of research work, unpublished reports on administrative studies and personal observations or suggestions of other range administrators. No claim is made as to the accuracy or completeness of studies or conclusions drawn.

All who read these RANGE IMPROVEMENT NOTES are encouraged to submit material for publication, or suggestions for improving its usefulness. Full credit will be given for any material used.

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Patterns and Rates of Pinyon-Juniper Invasion
and Degree of Suppression of
Understory Vegetation in the Great Basin

by

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for

Range Improvement Notes
Intermountain Region, U.S. Forest Service

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About the Authors

Neil West grew up on a ranch in southeastern Oregon. After receiving B.S. and Ph.D. degrees in plant ecology at Oregon State University, he worked for a short time at the Oregon Forest Research Laboratory. He came to Utah State University in 1974 where he is now Professor of Range Ecology. He served as Visiting Professor in the Institute of Ecology at the University of Georgia in 1970-71 and is Mellon Visiting Professor in the School of Forestry and Environmental Studies at Yale University during the present academic year.

Robin Tausch and Ageli Nabi were graduate students under Dr. West's direction. They have moved on to teaching and research positions elsewhere.

BACKGROUND OF PROJECT

In early 1972, the Intermountain Forest and Range Experiment Station funded Neil West at Utah State University and Paul Tueller of the University of Nevada to cooperatively develop a synecological study of the pinyon-juniper woodlands of the Great Basin. A major objective of that intitial study was the development of a habitat-type style classification of these woodlands similar to those the Forest Service had successfully developed and applied in the management of Forests and rangelands in the Pacific Northwest and Montana.

The habitat-type approach requires the availability of some vegetation at or near climax or stable condition. Early in the study it became obvious that there was only a fragmentary understanding of the successional patterns operating in these woodlands and it was unclear what woodlands in climax or stable conditions should be like. Although it was known that examples of these ecosystems had undergone considerable historical change (West et al. 1975), it was not known how widespread these phenomena were or how the rates and consequences of change might differ with varying levels and combinations of environmental influences over the study area. Because of these questions, a second study was begun in 1975 at Utah State University with joint funding by the U.S. Forest Service and the Utah Agricultural Experiment Station.

A basinwide type map, floristic list, and a discussion of latitudinal, longitudinal, and elevational variation in total floristic diversity and distribution of major species and soils have previously been published (West et al. 1978a, b, Tueller et al. 1979, West et al. 1979). The floristic richness, general position, and width of the woodland belts are largely related to climatic variation (West et al. 1978a). Some higher-order subdivisions of the woodlands were derived largely on the concomitance of floristic and topographic variation (Tausch et al. 1979). However, because of the requirements for understanding successional patterns, a full treatment of the original data set for development of lower-order synecological subdivisions of more utility for land managers awaited the results of the second research project.

The second project has yielded data enabling a better understanding of the successional processes and allowed patterns and rates of successional change to be related to environmental factors. It is now possible to segregate the data collected during the first research project by successional status and develop classifications based on a firmer understanding of what potential vegetation might be expected to occur on various kinds of sites.

This detour, taken to attain the earlier objective of synecological classification, has unearthed many other results; some planned, some serendipitous, but all leading to a better understanding of the dynamics of these woodlands and vegetation in general.

OBJECTIVES

The specific objectives of the second project were:

1. To identify the pattern and rates of pinyon and juniper tree invasion and degree of suppression of understory forage species and relate them to site differences by way of a simple mathematical model.

2. To develop the means of determining the rates at which acreage has been removed from high forage production in the past and is likely to be removed in the future.

APPROACH

Two concomitant, mutually supportive approaches were employed to reach the stated objectives. The first approach involved the inference of successional status and rates of change from objectively placed plots within a random set of mountain ranges. These data were collected in the first study. Successional status and rates of change in vegetation were then directly related to latitude, longitude, altitude, slope, exposure, landform, geological substrata, and soils. Indirect relationships were drawn to climatic and land use history information. From this analysis, a basinwide understanding of current woodland successional status and rates of change has emerged (Nabi 1978).

The basinwide work has been totally empirical. If we are ever going to be able to predict what will happen in the future, we cannot rely solely on the assumption that what has happened in the past will repeat itself in the future. We should understand the mechanisms by which succession occurs. Then, if the same mechanisms are operating in the future, similar patterns of change can be more confidently predicted. Although observations of successional variations over a great many sites are helpful in forming impressions and thus hypothetical mechanisms, detailed analysis of community structure, and dynamics can feasibly be done at only a few sites.

Our second approach was to choose a site on the western slope of Indian Peak in the Needle Range of western Beaver County in southwestern Utah. A very thorough collection of plant density, cover, and biomass data was made for a chronosequence of seral communities all occuring on the same site in terms of physical variables.

A conventional, totally empirical approach to the studies of this one site would have left the problem of how representative the site was of Great Basin pinyon-juniper woodlands in general. Accordingly, it was necessary to develop ways of being able to extrapolate the understanding of successional mechanisms to other woodland sites. This challenge has stimulated the development of a new approach to describing individual plant growth, population, and community successional dynamics (Tausch

1979). This general mathematical model of successional change in forests and woodlands, based on competition theory and dimensional analysis is believed to have importance far beyond the original needs of this project. However, its first application is made to the project at hand.

The details of the methodology used in all these phases of the project are discussed in the papers listed in the Literature Cited section.

The following is a brief version of the main results and their implications unencumbered by the details of the statistical and mathematical manipulations required to reach those ends.

RESULTS AND DISCUSSION

Examination of the basinwide data indicates that pinyon dominates most of the woodlands sampled (Table 1). Furthermore, pinyon is responsible for most of the increase in tree density and dominance over the past 150 years (Fig. 1). Where pinyon occurs, it both grows faster and more effectively outcompetes sagebrush-grass vegetation than juniper (Tausch 1979). Pinyon gets larger in size, and except for scattered individual junipers in some stands, lives as long as juniper. At the lowest elevations, where only juniper occurs, juniper will eventually dominate until man intervenes.

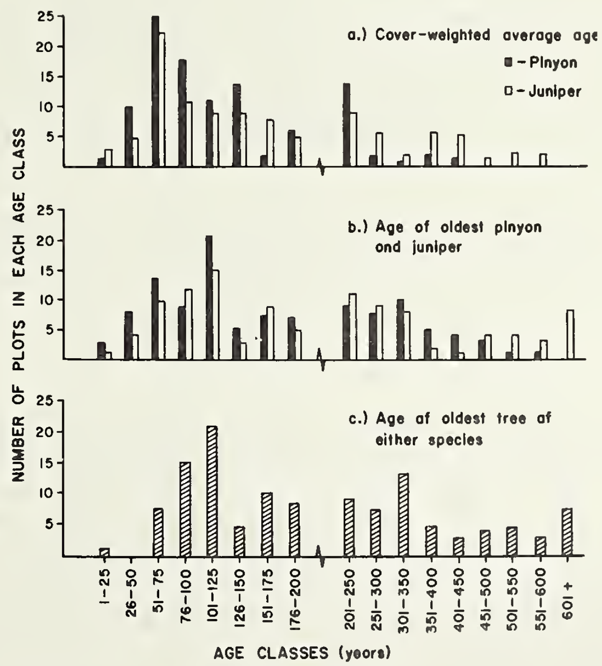

Figure 1 Frequency distribution of the sampled plots according to their cover-weighed average age (a) and age of oldest tree (b) of pinyon and juniper, and (c) age of oldest tree of either species.

Table 1. Average total vegetal cover and relative cover (%) of tree species of each mountain range sampled at the intermediate level, all of the plots on each mountain range, and all the plots per each exposure per mountain range.

	Average Total Vegetal Cover	Relative Juniper Cover (RJ%) all Aspects	Relative Pinyon Cover (RP%) all Aspects	North Aspect		East Aspect		South Aspect		West Aspect	
				RJ%	RP%	RJ%	RP%	RJ%	RP%	RJ%	RP%
CALIFORNIA											
White Mountains	31.5	10	90	4	96	*	*	27	73	00	100
IDAHO											
Black Pine Peak	41.9	100	00	*	*	100	00	100	00	100	00
NEVADA											
East Humboldt Range	34.9	45	55	*	*	4	96	83	17	48	52
Excelsior Range	23.9	00	100	00	100	00	100	00	100	00	100
Goose Creek Range	25.4	00	00	*	*	100	00	100	00	100	00
Highland Range	32.6	43	57	37	63	34	66	58	42	39	61
Monitor Range	50.0	12	88	2	98	8	92	19	81	18	82
Schell Creek Mountains	37.2	46	54	21	79	41	59	67	33	70	30
Shoshone Range	40.7	13	87	4	96	00	100	10	90	6	94
Toana Range	39.4	55	45	100	00	43	57	23	77	57	43
Toiyabe Range	48.4	24	76	2	98	33	67	00	100	7	93
UTAH											
Confusion Range	26.3	48	52	*	100	69	31	*	*	27	73
Enterprise-Beryl Hills	35.8	70	30	61	39	97	3	65	35	82	18
Garrison Hills	32.4	84	16	68	32	100	00	*	*	*	*
Mineral Mountains	30.5	63	37	99	1	50	50	60	40	49	51
Needle Range	34.1	40	60	35	65	46	54	49	51	36	64
Pilot Range	43.2	45	55	45	55	47	53	37	63	49	51
Tushar Range	27.1	64	34	53	47	65	35	58	42	100	00

* No stands were available and thus no sampling occurred at that aspect.

Mid-elevations (2000-2400 m) in the Great Basin have the oldest trees and generally highest tree dominance levels. Total tree cover and density declines both above and below this belt (Fig. 2). Pinyon

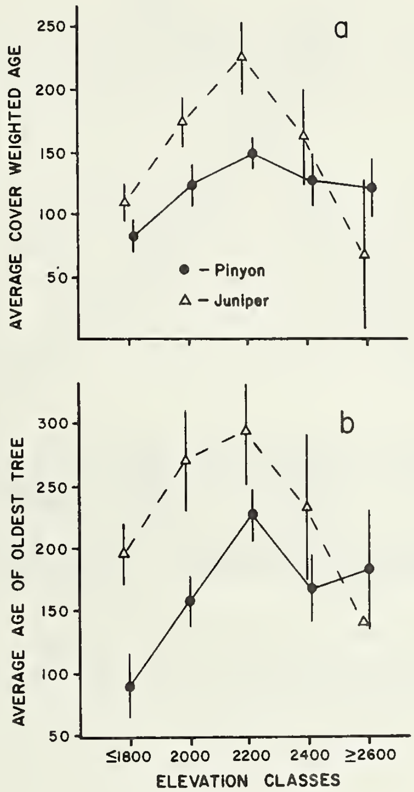

Figure 2 Cover-weighted average age (years) (a) and oldest tree (b) for the plots at each elevation interval. Vertical bars equal one standard error of the mean.

increases in relative dominance with increasing elevation, whereas juniper increases at lower elevations (Fig. 3). Over about the past 125 years, both species have thickened up their densities in the mid-elevations and invaded former grasslands and shrublands at both higher and lower elevations. The success of juniper expansion has been greater at lower elevations. Compared to pinyon, the ability of juniper to tolerate these sites is at least partially due to its somewhat higher resistance to drought, spring frost, and fire. The rate of successional changes and successional status (Fig. 4) progressively declines from the optimum elevation.

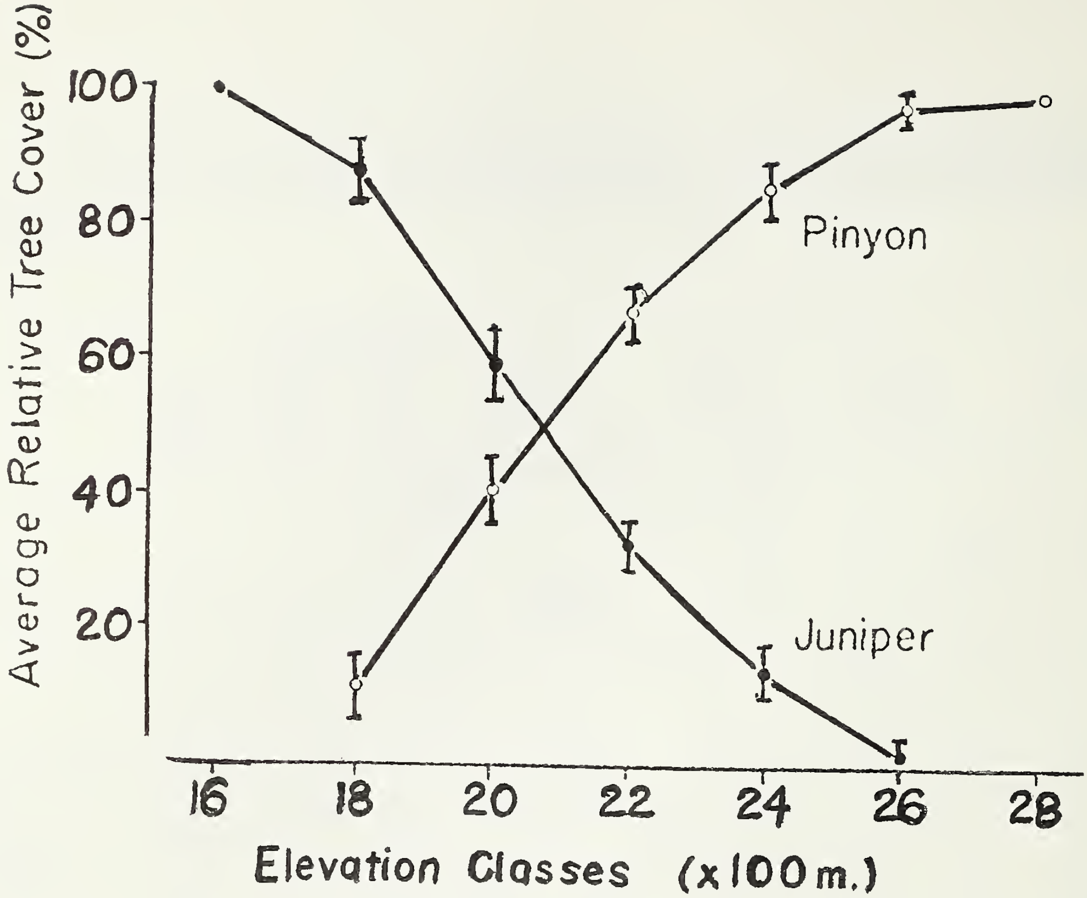

Figure 3 Average relative cover (%) of pinyon and juniper for the plots of each elevational interval (all aspects combined). Vertical bars equal one standard error.

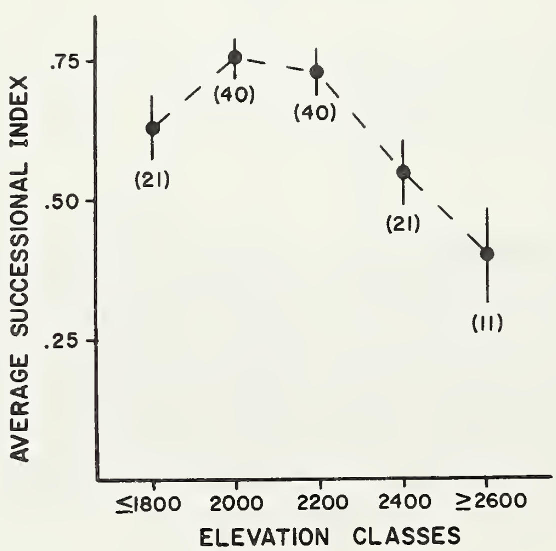

Figure 4 Average successional status of the plots at each elevational interval. Vertical bars equal one standard error. Number of plots found at each elevation in parenthesis.

Basinwide patterns of successional status and rates of successional change are apparently unrelated to longitude, geological substrata and soil classification at the great group level. The woodlands are, however, more prevalent, the tree dominance is greater, and the replacement of the understory by trees occurs over a shorter time span on soils with restricted rooting depth (Nabi 1978, West et al. 1979).

The latitudinal and altitudinal patterns of successional status and rate of change are apparently related to favorable climate. These are usually sites located where intermediate altitudes and latitudes make up the bulk of the landscape (Nabi 1978).

Analysis of the size-age-form classes, actual ages of a sub-sample, and cover-weighted mean ages of the trees (Fig. 2) indicates that the most rapid change in Great Basin woodlands began about the same time (about 1860) all across the Great Basin. The pulse of the tree regeneration coincides with warmer, wetter climatic trends (Wahl and Lawson 1970, LaMarche 1973 and 1974) and large populations of livestock (Blackburn and Tueller 1970).

The changes were believed to have been later accelerated by fire prevention and suppression policies and the buildup of herds of mule deer in the 1950's and 1960's. The relative importance of these causes cannot easily be separated because they are concomitant and few, if any, opportunities exist to view vegetation where only one likely cause was operative.

In the 50 year period from 50 to 100 years ago, approximately twice as many pinyon and juniper trees became established as in the 50 year period that preceeded it (Fig. 1). Most of the tree establishment in the 100 to 150 years before the present period occurred between 100-125 years ago. One-fourth to one-third (depending on species) of the plots sampled had cover-weighted mean ages of less than 150 years. Forty percent of the plots apparently had no trees over 150 years old. Thirty-six percent of the plots had no trees over 125 years old. Nineteen percent of the plots had no trees over 100 years old. Adding an estimate of the number of the very youngest stands, which were missed due to the arbitrary sampling criteria, indicates that at least half of the present Great Basin pinyon-juniper type is of post-settlement age derivation. Since we know that these trees can attain considerable age (1000 years plus), some very different communities from those found under pristine conditions have developed and are continuing to change at accelerating rates.

The foregoing provides an appreciation of the extensiveness and degree of successional change taking place in woodlands over the Great Basin as a whole. Woodland successional status and estimated rates of change have been correlated with the major, easily-measured environmental variables and some general patterns have emerged. It was not possible, however, in the overall study to gather enough detailed data to begin to really understand the mechanisms bringing change to these woodlands. Only at the Indian Peak study area, during the last two years of the

study, was it posible to focus in on the details of late secondary succession for a particular site. The results have been most revealing.

The Indian Peak successional sequence shows a distinct decrease in understory cover (Fig. 5) and weight with increasing tree canopy development. In addition, we have shown that the two tree species are capable of supporting 8 to 9 times more green tissues than all the understory species would be capable of, even if no trees existed on the site.

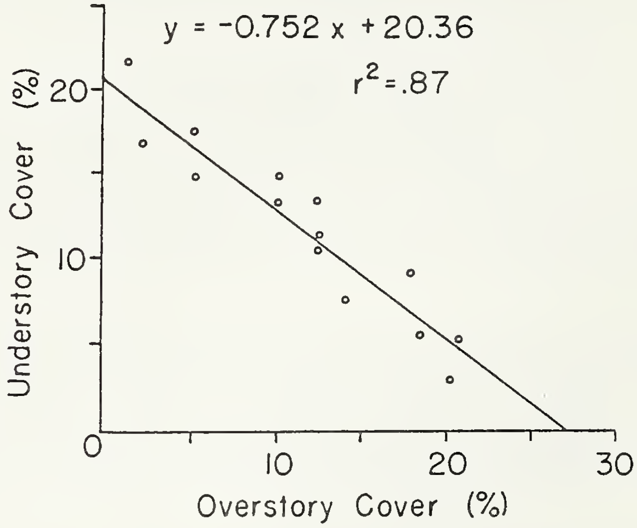

Figure 5 Simple linear regression analysis of tree to understory cover (%) over a full sere of increasing tree dominance for a site on the eastern flank of Indian Peak, southwestern Utah (Tausch 1979).

When one adds to this, the wood production, the potential biomass dominance by trees on the site is overwhelming. Stated another way, trees can apparently support an equal biomass of live tissue on roughly one-eighth the resources of space, water, nutrients, etc., that understory plants require or can utilize. Trees gain competitive dominance over shrubs and herbaceous species far earlier in the sere than has been previously realized. Tree dominance exceeds that of the understory when the trees reach one-third of their climax potential (about 60-70 years after their re-invasion). The height of the trees at this point is only about double that of the shrubs (1 to 2 meters), but the understory species decline at an increasingly rapid rate as the trees rapidly grow roots into their moisture supply.

Managers do not generally begin to notice the loss of forage until much more aboveground tree growth and more startling losses of understory

have occurred. Weight of understory, and thus available forage, is being lost at a much more rapid rate than indicated by the cover changes.

There appear to be four stages in the takeover of an understory community by the tree species. The first three stages encompass periods of 30-40 years each. The time is less on the better sites and more on poorer sites.

The first stage is from tree seedling establishment until the trees are about the size of the largest shrubs on the site (½ to 3/4 meters tall). During this stage, the presence of trees is not obvious without close inspection, particularly under shrubs.

The second stage involves the time necessary for most of the trees on the site to reach one to two meters in height. At the end of this stage only about 1/3 or less of the understory productivity has been lost.

By the end of the third stage, 2/3's to over 3/4's of the understory productivity has been lost and the community becomes truly tree-dominated. The rapid loss during the third stage is apparently due to the rapid increase in tree size. At the end of the second stage, the trees are large enough that the understory no longer provides significant competition. During the third stage, the annual total amount of tree biomass per unit area is rapidly increasing even though the annual increase of tree biomass per unit of existing biomass is slowly declining.

Stage one was apparently very prevalent across the Great Basin in the 1860's through 1890's. Stage two was completed on the better sites during the 1940's and 1950's. It was in this period that rapid understory depletion began on these sites. Some form of understory depletion was evident on most of these sites at the time of our sampling. Much of the remaining Great Basin woodlands are now moving into stage three and are now undergoing a rapid decline in understory productivity.

If present trends continue, by the year 2000, all but the more marginal sites for Great Basin pinyon-juniper woodlands will have lost most of their understory productivity. The beginning of the rapid understory decline on better sites in the late 1940's and early 1950's coincides with the commencement of public and private concern and the beginnings of conversion attempts. Substantial reductions in the forage available from these woodlands for both game and livestock has occurred, is occurring, and barring some major change, will continue to occur until all sites climatically favorable for tree survival are dominated by these more efficient plants. Control of grazing animals will not change the patterns. Only the more drastic actions of prescribed burning, mechanical or chemical treatment will allow return of forage producing conditions.

The combined results of both parts of the study show that though much understory has been traded for tree cover during the past 100 years, even more solid tree dominance appears on the horizon. The trajectory of successional change was set over a hundred years ago. Trees are the

climatic climax dominants. Without periodic fire, mechanical or herbicidal treatment, the herbaceous and shrubby species cannot be maintained. It is likely that heavy livestock grazing in the last century accelerated the conversion of savannah into dense vegetation dominated by woody species. Trees had the competitive advantage on shrubs. The increase of big game populations in the 1940's through 1960's probably accelerated the demise of many shrubs under pinyon-juniper canopies. Much of the type is now almost exclusively trees. Our studies indicate that succession toward further tree dominance in the remainder of the type will further accelerate as it moves into later stages of succession. The option of prescribed burning will be lost as understory can no longer sustain a ground fire (Blackburn and Bruner 1975). If improved forage is a management objective, the more costly and politically sensitive mechanical and herbicidal methods will have to be employed. Chaining or cabling of trees with debris left in place (essentially setting succession back to only the beginning of stage three) and no followup prescribed burning will buy less than 20 years of improved forage (Tausch and Tueller 1977). Chaining or cabling with followup prescribed burning or ricking of debris and seeding will gain at least 50 years of improved forage supplies (Aro 1975). Not everyone appreciates the aesthetics or rationale of such operations and proposers of such action may expect considerable objections from environmentalists (Lanner 1977, West 1978).

If production of tree-derived products ever becomes economically feasible, objections to tree removal rather than destruction may be less. Our research will also provide information for projecting supplies of those materials.

Present studies provide only very generalized views of successional changes over the Basin as a whole and detailed understanding at one site. These views are, however, thought provoking enough that managers of these woodlands should be encouraged to re-examine the situation in their locale and make decisions on present and future woodland management strategies.

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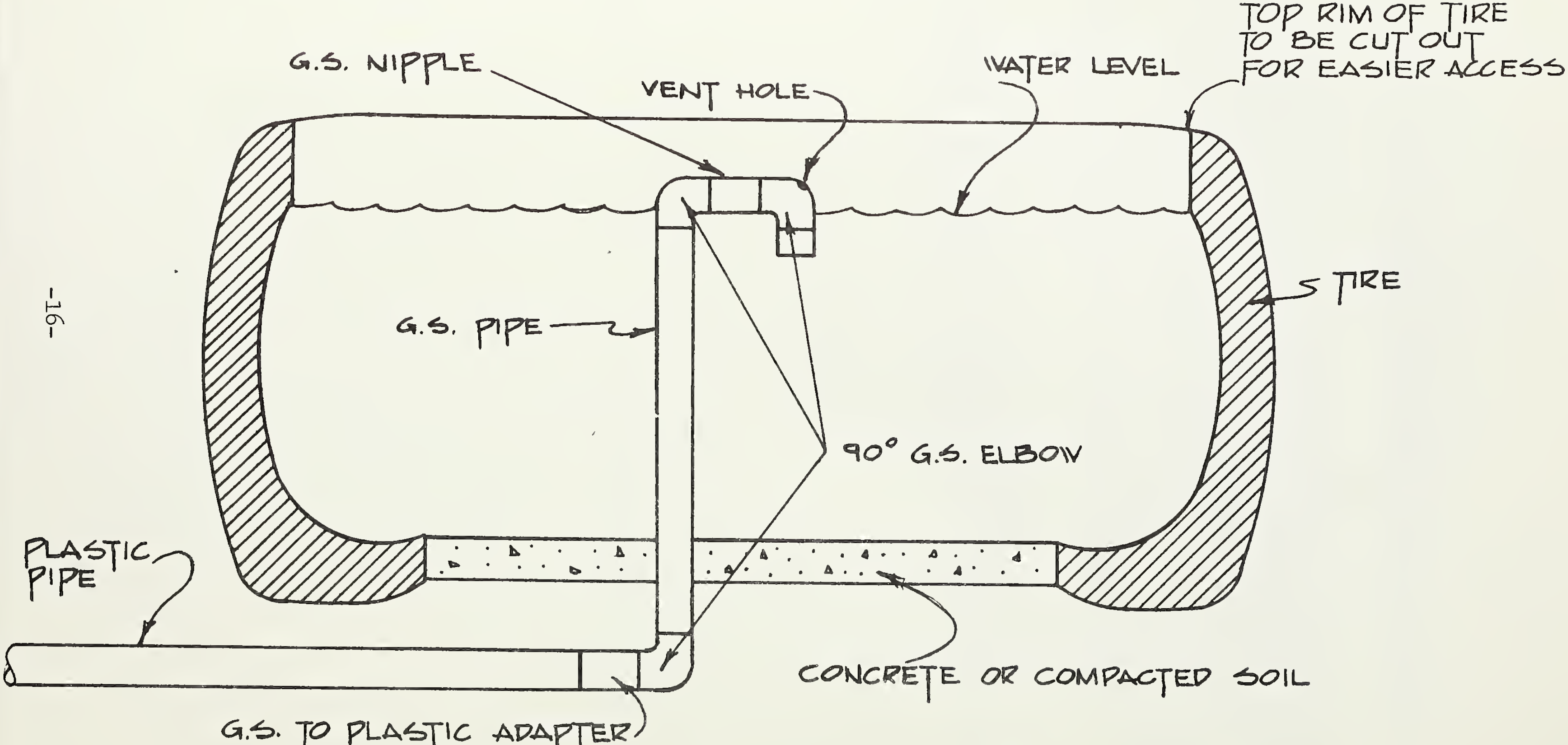
RUBBER TIRE TROUGH

Submitted by Rusty Orr and Chuck Arendts, Boise N.F.

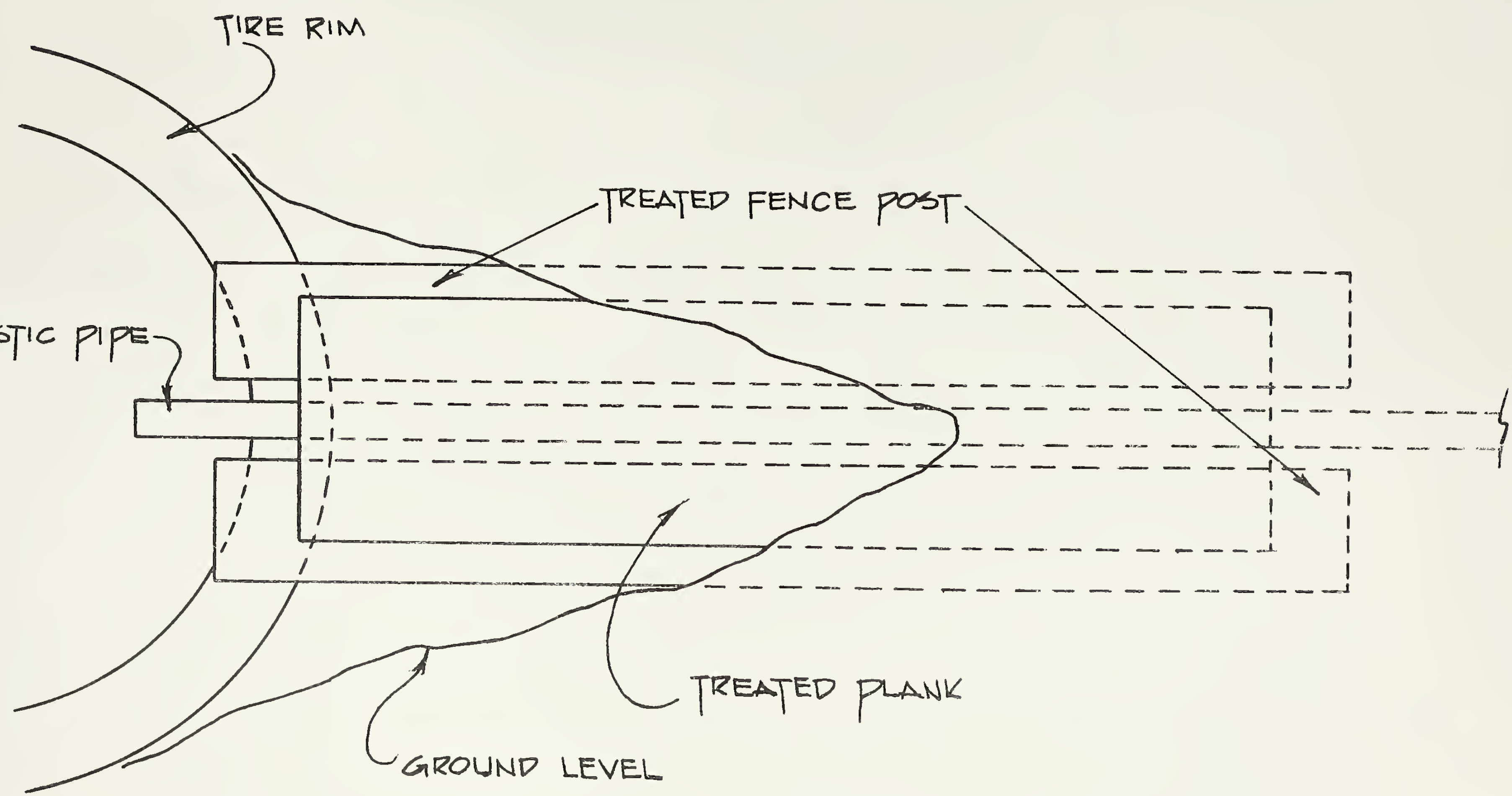
The top sidewall of a discarded implement tire is cut away to allow animals access to the water. The bottom of the tire is sealed with concrete or compacted clay. Leaks can be sealed with hydroseal. The outlet pipe should be placed in the center of the trough to prevent damage by livestock. Although not shown here, some means should be provided to keep animals out of the trough and allow the small critters an opportunity to safely get a drink. See Plan R4-RM31 in FSH 2209.22.

OUTLET SECTION

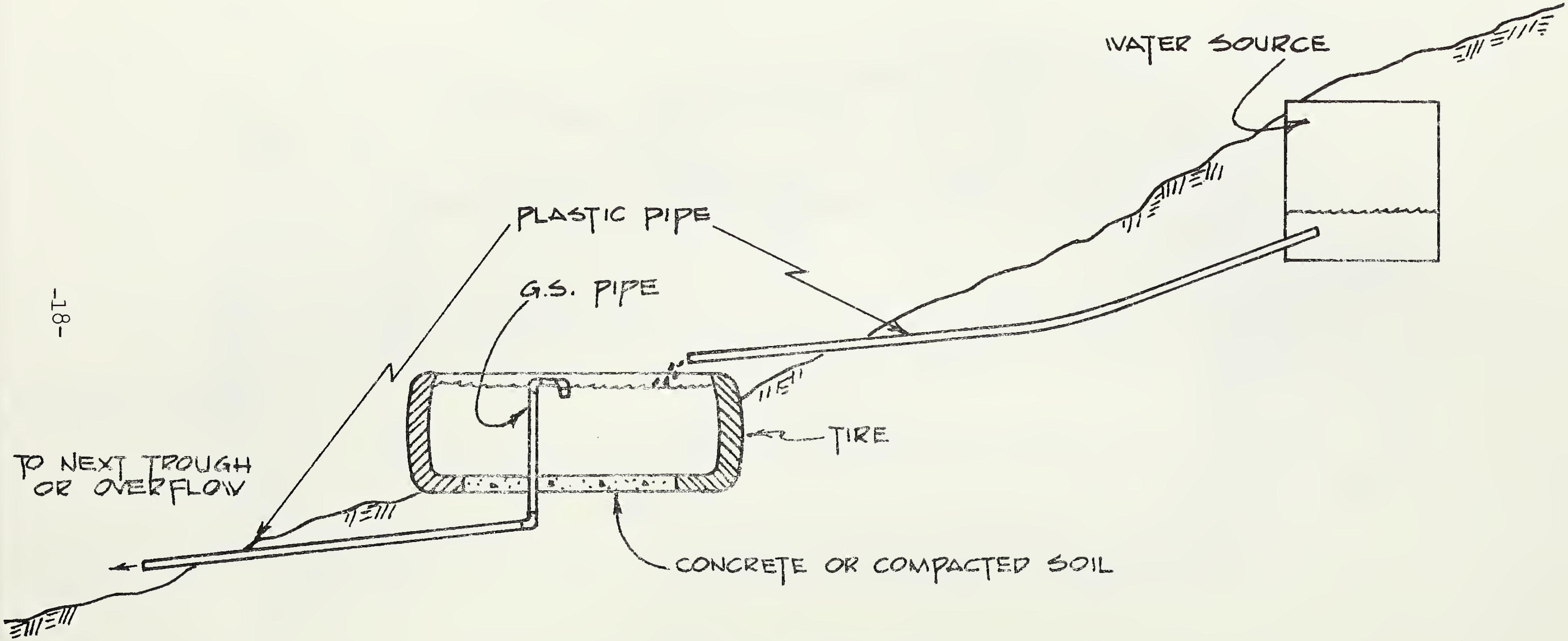


RUBBER TIRE TROUGH

INLET (PLAN VIEW)



RUBBER TIRE TROUGH



LOCATION SECTION

RUBBER TIRE TROUGH